

SECTION 02225

COMPACTED CLAY LINER AND CAP

PART 1 GENERAL

1.01 SCOPE

- A. This section includes compacted clay liner and cap material and placement.

1.02 RELATED SECTIONS AND PLANS

- A. Section 02100 - Surveying
- B. Section 02200 - Earthwork
- C. Section 02240 - Protective Layer
- D. Section 02772 - Geosynthetic Clay Liner
- E. Section 13000 - Borrow Area Management
- F. Part 6 - Statement of Work
- G. Part 8 - Environmental Health and Safety, and Training Requirements
- H. Part 9 - Quality Assurance Requirements

1.03 REFERENCES

- A. Latest version of American Society for Testing and Materials (ASTM) Standards:
 - 1. ASTM D 422. Standard Test Method for Particle-Size Analysis of Soils.
 - 2. ASTM D 698. Standard Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures using a 5.5 pound Rammer and a 12-in. drop.
 - 3. ASTM D 2487. Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 4. ASTM D 4318. Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

5. ASTM D 5084. Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter.
 6. ASTM E 946. Standard Test Method for Water Absorption of Bentonite by the Porous Plate Method.
- B. Reference Reports addressing OSDF and borrow area site subsurface conditions:
1. "*Geotechnical Investigation Report, On-Site Disposal Facility*" [Parsons, 1995]. This report contains geotechnical data for the subsurface soils in the OSDF area.
 2. "*Disposal Facility Pre-Design Geotechnical Investigation, Soil Investigation, Soil Investigation Data Report, CERCLA/RCRA Unit 2*" [Science Applications International, 1995]. This report presents geotechnical data for the subsurface soils in the OSDF area.
 3. "*Geotechnical Data and Evaluation Report for East and South Field Borrow Areas*" [Parsons, 1996a]. This report contains geotechnical data for the subsurface soils in the borrow area.
- C. Test Pad Program Final Report, On-Site Disposal Facility, Volumes I-III, [GeoSyntec, 1997].

1.04 SUBMITTALS

- A. Include a list of the equipment and description of methods to be used for compacted clay liner and cap construction to include mechanical screens for removal of rock larger than 2 inch, soil processing, moisture conditioning, and compaction in the Earthwork Work Plan specified in Section 02200. If alternative equipment is proposed, provide a detailed demonstration that the proposed equipment is in all aspects functionally equivalent to the equipment described in this Section.
- B. Submit to the Construction Manager for review within 30 calendar days from Notice to Proceed, a specification sheet for the proposed bentonite powder or granules and a 5-pound representative sample of the material.

1.05 HEALTH AND SAFETY REQUIREMENTS

- A. Environmental, health and safety, and other training requirements shall be as specified in Part 8 of the Contract Documents.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Material for compacted clay liner and cap construction shall be obtained from the On-Site Disposal Facility (OSDF) excavation included in this Contract and the borrow area stockpiles indicated on the Construction Drawings. Segregate granular lenses and other nonconforming soils in the excavation or borrow area and use only those materials meeting the material requirements of this Section. Minor granular lenses that when readily mixed with surrounding soil result in a material that meets the material requirements of this Section need not be segregated.
- B. Borrow area management shall be in accordance with Section 13000.
- C. Identify sources and volumes of clay liner and cap materials required at least 15 calendar days prior to use to allow for conformance testing of soil by the CQC Consultant. Clay liner and cap material meeting the requirements specified in this section shall be used in compacted clay liner and cap construction.
- D. Compacted clay liner and cap material shall meet the following requirements:
 - 1. be classified according to the Unified Soil Classification System (ASTM D 2487) as lean clay (CL) or fat clay (CH);
 - 2. have a plasticity index (ASTM D 4318) of at least 10 percent, but less than 40 percent;
 - 3. meet the following particle size requirements (ASTM D 422):
 - a. 100 percent of the particles having a maximum dimension not greater than 2 inches (50 mm);
 - b. not more than 10 percent of the particles, by weight, having a dimension greater than 0.75 inches (20 mm);
 - c. not less than 50 percent of the particles, by weight, passing through the standard U.S. No. 200 standard sieve; and
 - d. not less than 15 percent of the particles, by weight, having a maximum dimension not greater than 0.002 mm.
 - 4. have a hydraulic conductivity of not more than 1×10^{-7} centimeter per second (cm/s) when constructed in accordance with this Section and when tested in the laboratory in accordance with ASTM D 5084 at a confining pressure of 5 pounds per square inch (psi).
- E. Water for moisture conditioning clay liner or cap material shall be from the on-site water source shown on the Construction Drawings.

- F. Bentonite granules shall contain at least 85 percent sodium montmorillonite, and a water adsorption of at least 500 percent when tested in accordance with ASTM E 946.
- G. Soil-bentonite mix for backfilling perforations shall consist of a minimum of 10 percent by weight bentonite granules mixed with clay liner and cap material (by dry weight basis).

2.02 EQUIPMENT

- A. Equipment for excavation shall be as specified in Section 02200.
- B. Use mechanical screening plant to remove rock particles having a maximum dimension of greater than 2 inches. Capacity of the screening plant shall meet or exceed the clay liner material placement rate. Electric power will not be available.
- C. Use hauling and placing equipment to place clay liner and cap material in uniform loose lift thicknesses as specified in this Section.
- D. Use tank trucks, pressure distributors, soil stabilizers, or other equipment designed to apply water uniformly and in controlled quantities to moisture condition clay liner material and to prevent drying of soil surfaces.
- E. Use grading equipment to achieve uniform layers, sections, and smoothness of grade for compaction and drainage.
- F. Use the following soil stabilizer equipment for processing clay liner and cap material:
 - 1. Caterpillar SS250 soil stabilizer with water spray bar; or
 - 2. HAMM RACO 250 or 550 soil stabilizer with water spray bar; or
 - 3. approved equal.
- G. Use the following soil equipment for compacting clay liner and cap material:
 - 1. Caterpillar 815B; or
 - 2. approved equal.
- H. Use hand compaction equipment such as a walk-behind pad-foot compactor or hand tamper to obtain required compaction in areas inaccessible to large compaction equipment.

- I. Use the following equipment for sealing the compacted clay liner and cap lift surfaces:
 1. Caterpillar CS563; or
 2. equivalent self-propelled smooth drum roller approved by the Construction Manager.

PART 3 EXECUTION

3.01 GENERAL

- A. Perform construction activities in such a manner that equipment operating in radiologically controlled areas (RCA) do not operate in non-RCAs. Equipment operating in RCAs shall be decontaminated and radiologically surveyed by the Construction Manager prior to exiting for use in non-RCA areas.
- B. Dust control measures shall be in accordance with Part 6.
- C. Continuously remove visible rock particles with a maximum dimension larger than 2 inches during clay liner and cap material placement, processing, and compaction.

3.02 MATERIAL SCREENING AND STOCKPILING

- A. Locate mechanical screening plant(s) for removal of rock from clay liner and cap material excavated from the OSDF cell excavation, stockpiles, and borrow area in certified area south of OSDF Cell-3 and/or in borrow area indicated on the Construction Drawings.
- B. After installation and setup of the mechanical screening plant(s) is complete, notify Construction Manager for safety inspection. Do not operate screening plant(s) prior to completion of the Construction Manager safety inspection.
- C. Stockpile screened clay liner and cap material in approximately 5,000 cubic yard stockpiles for clay liner conformance testing and evaluation. Notify Construction Manager when each stockpile is ready for conformance testing. Construction Manager will notify the Contractor of approval of the clay liner and cap material for placement 15 calendar days from the date that a stockpile is ready for the conformance testing.
- D. Process clay liner and cap material larger than 2-inch mixed with soil clods and rock particles and containing more than 50 percent soil clods after screening to break up the soil clods. Rescreen this process material.

- E. Stockpile clayey rockfill particles larger than 2-inch from the screening in the certified area at designated location(s) approved by the Construction Manager.

3.03 COMPACTED CLAY LINER AND CAP PERFORMANCE CRITERIA

- A. The moisture content and dry density of clay liner and cap material placed shall be within the acceptable permeability zone (APZ) defined as those combinations of moisture content and dry density that meet the following three criteria: (i) moisture content that results in a degree of soil saturation of at least 90 percent; (ii) moisture content not greater than 3 percentage points wet of the standard Proctor optimum moisture content (ASTM D 698); and (iii) dry unit weight of at least 95 percent of the standard Proctor maximum dry unit weight (ASTM D 698). The CQC Consultant will provide the Contractor with specific moisture content ranges and associated dry unit weights that satisfy these criteria for each material used in compacted clay liner and cap construction.

3.04 MATERIAL PLACEMENT

- A. Excavate, screen, and stockpile clay liner and cap material at least 15 calendar days prior to start of clay liner and cap placement.
- B. Place clay liner and cap material only after completion of the following activities:
 - 1. conformance testing and evaluation of material by CQC Consultant;
 - 2. performance evaluation of previous work including evaluation of Contractor's survey work by CQC Consultant; and
 - 3. approval of the clay liner and cap material by the Construction Manager.
- C. Prepare subgrade in accordance with Section 02200 and survey in accordance with Section 02100 prior to scarification. Scarify the surface on which the first lift of clay liner material is to be placed to a depth of 2 inches using the soil stabilizer. In the event the scarifier cannot operate on the cell slopes, scarify the subgrade by using a disc, tracking back and forth with a dozer, or a combination of both. Moisture content for the subgrade shall be as specified for the compacted clay liner and cap performance criteria.
- D. Prepare contouring layer in accordance with Section 02240 and survey in accordance with Section 02100 prior to beginning compacted clay cap construction. Scarify the surface on which the first lift of clay cap material is to be placed to a depth of 2 inches by tracking with a dozer. Moisture content for contouring layer shall be as specified for compacted clay liner and cap performance criteria.

- E. Construct compacted clay liner and cap to the grades and minimum thicknesses shown on the Construction Drawings. The thickness of the compacted clay liner and cap at any location shall be measured perpendicular to the plane of the slope at that location.
- F. Remove visible rock particles with a maximum dimension larger than 2-inches from the compacted clay liner and cap material during placement, spreading, compaction, and other working of the compacted clay liner and cap. Place rock particles removed from the clay liner and cap material in a stockpile in an area approved by the Construction Manager.
- G. Prior to compacted clay liner or cap placement, ensure the surface on which the clay material is to be placed is free of debris, branches, vegetation, mud, ice, or other deleterious material.
- H. In areas where compaction is to be performed using the Caterpillar 815B, or equivalent equipment, place the clay liner and cap material in loose lifts with a maximum thickness of 8 inches. The first lift may be placed in a 10-inch thick loose lift. In areas where compaction is to be performed using hand-operated equipment, place the clay liner and cap material in loose lifts with a loose thickness of 4 inches \pm 1 inch. Loose lift thicknesses will be measured after spreading but before processing with the soil stabilizer.
- I. Do not place a succeeding lift of clay material over any area until the CQC Consultant has completed performance testing of the lift in that area.
- J. Prior to compacting a succeeding lift of material over a previous lift, scarify the previous lift to a depth of 2 inches using the soil stabilizer. Scarification may occur either before or after placement of the succeeding lift. In either case, set the stabilizer mix depth appropriately to achieve the required depth of scarification. Moisture condition the succeeding lift in accordance with this Section. In the event the scarifier cannot operate on the cell slopes, scarify each preceding lift prior to placing the next lift by using a disc, tracking back and forth with a dozer, or a combination of both. In scarifying lifts of the compacted clay cap, do not use a method that results in contamination of the soil stabilizer by impacted material of the contouring layer.
- K. The trafficking of scarified surfaces by trucks or other equipment, except stabilizer, moisture conditioning, and compaction equipment, is not permitted.
- L. The maximum acceptable soil clod size after processing with the soil stabilizer is 3 inches. Reduce clod size using the soil stabilizer. Soil clumps, consisting of an agglomeration of smaller clods, will not be considered a clod for purposes of this section. After making each pass of the soil stabilizer, remove visible rock particles with a maximum dimension

- larger than 2 inches. A minimum of one pass of the soil stabilizer shall be required for each lift of clay liner and cap material.
- M. Moisture condition the loose lift of clay liner and cap material prior to compaction if necessary. Distribute the moisture through the loose lift using the soil stabilizer. Moisture condition, if necessary, as follows:
1. If the clay liner and cap material is drier than required, process the material with the soil stabilizer to obtain a uniform consistency, distribute water uniformly into the soil to achieve the required moisture content, then process the material again with the soil stabilizer to obtain uniform mixing. The CQC Consultant will check the moisture content of the soil at the completion of these three steps and/or after compaction. Repeat the latter two steps if the measured moisture content is not within the acceptable range given in this Section.
 2. If the clay liner and cap material is wetter than required, dry the material by processing with the soil stabilizer. The CQC Consultant will check the moisture content of the soil at the completion of processing or compaction. Repeat the processing if the measured moisture content is not within the acceptable range specified in this Section.
 3. After making each pass of the soil stabilizer, remove visible rock particles with a maximum dimension larger than 2 inches.
- N. In the event the soil stabilizer cannot operate on cell slopes, process and moisture condition the clay soil at the base of the slope in accordance with this Section. After completion of processing and moisture conditioning, use a dozer to place the clay liner material on the slope in loose lifts with a maximum thickness of 8 inches. After placement of the clay liner material on the slope, remove visible rock particles with a maximum dimension larger than 2 inches.
- O. Do not place frozen clay nor place clay on frozen ground.
- P. Do not place compacted clay liner or cap material at temperatures below 32 degrees Fahrenheit (F), unless otherwise authorized in writing by the Construction Manager. If cold weather (<32 F) clay material placement and/or compaction is implemented, prepare and submit a written plan to the Construction Manager describing proposed cold weather placement and compaction procedures and the weather parameters for which cold weather operations are proposed. Include protection of work in accordance with the requirements of the succeeding item.
- Q. If compacted clay liner or cap material freezes after compaction, remove the frozen material, scarify the remaining unfrozen material, and replace material and compact in

accordance with this section. Do not reuse the frozen material until it has thawed and been reprocessed to an acceptable moisture content. Include the protective measures to be taken for placement, compaction, and protection of clay liner and cap material during freezing conditions in the Earthwork Work Plan specified in Section 02200. Protective measures may include the use of thermal blankets or a sacrificial soil layer.

- R. Do not place clay liner or cap material during periods of precipitation. Placement may occur during periods of misting or drizzle, but only if approved by the Construction Manager.
- S. Prepare the last lift of the compacted clay liner or cap to meet the minimum thicknesses and grades indicated on the Construction drawings. Meet the construction tolerance requirements given in this Section.
- T. Prepare the finished compacted clay liner and cap surface to be acceptable for placement of the overlying geosynthetic clay liner or cap in accordance with Section 02772.

3.05 MATERIAL COMPACTION

- A. Compact loose lifts using a minimum of six passes of the specified compaction equipment. Provide additional passes to achieve performance criteria specified in this section.
- B. For a dual-drum compactor with laterally-separated front and rear drums, a compaction pass is defined as one trip up and a staggered trip back to cover the uncompacted area between the drums (i.e., one full coverage).
- C. Compact corners, around pipes, around liner penetration boxes, and other areas inaccessible to driven compaction equipment using hand operated equipment to achieve performance criteria specified in this Section.
- D. Maintain compacted surface of clay liner and cap in moist condition to avoid crusting and desiccation. In the event crusting or desiccation occurs, rework the soil in accordance with the "Protection of Work" Article of this section.
- E. Construct the transition from an existing full-depth section of compacted clay liner or cap to the beginning of an adjacent section that is to be constructed subsequently by sloping (cutting back) the end of the full-depth section at 5:1 (horizontal:vertical) or flatter, scarifying the slope of the existing full-depth section at the transition, and then immediately begin placing the adjacent lifts of material.

- F. Operate compaction equipment to prevent damage to, or disturbance of, leachate piping, liner penetration boxes, and geosynthetic materials.

3.06 CONSTRUCTION QUALITY REQUIREMENTS

- A. The CQC Consultant will perform soil conformance testing on clay liner and cap material to establish compliance with this Section. The conformance testing to be performed and testing frequencies are given in the Construction Quality Assurance (CQA) Plan referenced in Part 9 of the Contract Documents. Provide equipment such as shovels, hand augers, and backhoes and labor to assist the CQC Consultant in obtaining conformance samples from excavations, stockpile, and borrow areas. Identify source(s) and quantity of clay liner and cap materials required from each source at least 15 calendar days prior to use.
- B. The CQC Consultant will perform soil performance testing on compacted lifts of clay liner and cap material to evaluate compliance with this section. The performance testing to be performed and testing frequencies are given in the CQA Plan.
- C. If the CQC Consultant's tests indicate that any portion of the compacted clay liner and cap does not meet the requirements of this section, the CQC Consultant will delineate the extent of the nonconforming area. Rework the nonconforming area until acceptable test results are obtained by the CQC Consultant.

3.07 PERFORATIONS

- A. Backfill perforations in the compacted clay liner and cap resulting from survey stakes or other activities. The CQC Consultant will identify perforations requiring backfill. Perforations resulting from nuclear density tests and sand-cone tests will be filled by the CQC Consultant.
- B. Prepare soil-bentonite mix for use in backfilling of perforations as specified in this Section. The mix shall consist of a minimum of 10 percent by weight bentonite granules mixed with clay liner or cap material by dry weight basis.
- C. Backfill perforations with soil-bentonite mix. Place soil-bentonite mix in these perforations in approximately 3-inch thick loose lifts and compact.
- D. Perforations in the compacted clay liner and cap resulting from nuclear density testing and sand-cone testing will be backfilled with bentonite powder or granules or the soil-

bentonite mix furnished by the Contractor and compacted by hand tamping by the CQC Consultant.

3.08 SURVEY CONTROL

- A. Survey the limits and elevations of the finished surface of the compacted clay liner and cap in accordance with Section 02100.

3.09 TOLERANCE

- A. Construct the compacted clay liner and cap to within 0.0 to +0.3 feet of the thickness shown on the Construction drawings.
- B. Construct the compacted clay liner and cap to within ± 0.2 feet of the grades indicated on the Construction drawings.

3.010 PROTECTION OF WORK

- A. Avoid crusting and desiccation cracking of compacted clay liner and cap. Regularly moisture condition the surface of the compacted clay liner and cap. If cracking is observed, scarify, moisture condition, and recompact the surface. Seal roll the surface of the clay to reduce evaporation, or alternatively protect exposed surfaces using light-colored or translucent membranes, such as Visqueen, that will inhibit drying of the clay.
- B. Repair areas of crusting or desiccation cracking. Scarify the surface of such areas to a depth of 2 inches or to the depth of the desiccation, whichever is greater, and then moisture condition, process, and recompact the area in accordance with the requirements of this Section.
- C. Seal roll the compacted clay liner or cap surface at the end of every working day and when precipitation is forecast.
- D. Use tarping, PVC geomembrane, or other means approved by the Construction Manager, to shed rainfall runoff and protect compacted clay liner and cap during periods of extended rain.
- E. Seal roll and make smooth the compacted clay liner or cap surface on which the geosynthetic clay liner is to be placed to facilitate intimate contact between the geosynthetic clay liner and the underlying compacted clay liner or cap surface.

- F If compacted clay liner or cap surface cannot be maintained in a moist condition to prevent desiccation, place a clay protection layer over the compacted clay liner or cap if construction of overlying layers or lifts is to be delayed more than 10 calendar days. Compact the clay protection layer by tracking. The loose thickness of the protective layer shall be 8 inches (nominal). The clay protection layer can also be used to protect compacted clay liner and cap against excessive rainfall.
- G Remove the compacted clay protection layer prior to placement of overlying lifts or the geosynthetic clay liner. The protection layer may be removed in sections in coordination with ongoing construction. Where the protection layer is removed, prepare the surface to receive an overlying lift or the geosynthetic clay liner and the finished surface as required by this section.
- H Protect the compacted clay liner from freezing as specified in this section.
- I Do not apply synthetic sealants or other chemical treatments to the compacted clay liner and cap material.

[END OF SECTION]